A REFLECTIION TYPE LIQUID CRYSTAL DISPLAY

FIELD OF THE INVENTION

[0001] The present invention relates to a reflection type liquid crystal display (LCD) and, more particularly, to a reflection type LCD having two matrix modes converged within a panel.

BACKGROUND OF THE INVENTION

[0002] Since the explosive growth in wireless communications is a worldwide phenomenon, the next generation of mobile phones, also known as 3G (third generation) or UMTS (Universal Mobile Telecommunication Services), is a technology that allows users to access e-mails, videos and webs via a mobile phone.

[0003] Many companies, such as Motorola and Samsung, have provided 3G mobile phones that possess two displays. These kinds of mobile phones offer people two viewing options. A large interior display is used for standard functions and an exterior one just shows a caller's ID or, time and date. According to this, the resolution of the interior display is much higher than the exterior one. The interior display with higher resolution is sometimes an active matrix liquid crystal display (AMLCD). The exterior display with less electrical consumption can be a passive matrix LCD (PMLCD).

[0004] A liquid crystal (LC) layer of the PMLCD is sandwiched between two glass substrates, which contain parallel sets of electrical lines (electrodes) in a row and column configuration to form a matrix. Every intersection is a pixel. When applying a voltage high enough across the pixel, the LC molecules are aligned to determine the gray scale of the pixel.

[0005] AMLCD is similar to the PMLCD. However, AMLCD further includes an electronic switch (e.g. thin film transistor ; TFT) at every pixel so as to provide faster switching . The addressing mechanism eliminates problems of the viewing angle and the brightness suffered by the PMLCD.

[0006] Referring to FIG. 1, a simple comparison between the AMLCD and PMLCD is shown. The electrical consumption is much less in PMLCD than in AMLCD. The resolution and contrast ratio, however, are higher in AMLCD than in PMLCD. The manufacturability of the AMLCD is more complex than that of the PMLCD.

[0007] In order to reduce the weight and thickness of the mobile phone that has two distinct LCDs, it's beneficial to converge the active and the passive matrix modes within one LCD panel.

[0008] A reflection type liquid crystal display includes a reflective plate , that reflects the external light which enters into the liquid crystal display. The reflected external light is used as a light source of the reflection type liquid crystal display. Hence, a backlight module serving as a light source is therefore unnecessary. For this reason, the reflection type liquid crystal display is generally adopted as a display in a portable terminal device such as a mobile phone. In brief, the reflection type liquid crystal display is superior to a transmission type liquid crystal display with respect to power consumption, thickness, and weight etc.

BRIEF SUMMARY OF THE INVENTION

[0009] Accordingly, an object of the present invention is to provide a reflection type liquid crystal display having at least two matrix modes converged within a panel.

[0010] Another object of the present invention is to provide a reflection type liquid crystal display having at least two matrix modes converged within a panel, wherein at least one matrix

mode thereof comprises an active matrix mode.

[0011] A reflection type liquid crystal display comprising a lower transparent substrate, a first transparent insulating layer, a reflective layer, a second transparent insulating layer, an upper transparent substrate, a first set of electrodes, a third transparent insulating layer, a fourth transparent insulating layer, a second set of electrodes, a first transparent alignment film, a second transparent alignment film and a liquid crystal layer is disclosed herein. On the first transparent substrate are fabricated a plurality of thin film transistors (TFT), and on the second transparent substrate is attached a color filter. The first transparent insulating layer, the reflective layer and the second transparent insulating layer are formed in turn on the lower transparent substrate, wherein the first transparent insulating layer is served to cover the transistors and to provide insulation and planarization. The first set of electrodes comprises a first lower electrode on the second transparent insulating layer and a first upper electrode on the color filter. The third and the fourth transparent insulating layers are formed on the first lower electrode and the first upper electrode respectively. The second set of electrodes comprises a second lower electrode on the third transparent insulating layer and a second upper electrode on the fourth transparent insulating layer. One of the first set of electrodes and the second set of electrodes is in active matrix mode. The first transparent alignment film is formed on the second lower electrode, whereas the second transparent alignment film is fabricated on second upper electrode. The liquid crystal layer is sandwiched between the first and the second alignment films. The reflective layer is used to reflect and diffuse the incident light from the upper transparent substrate.

BRIEF DESCRIPTION OF THE INVENTION

[0012] The foregoing aspects and many of the attendant advantages of this invention will

become more readily appreciated and understood by referencing the following detailed description in conjunction with the accompanying drawings, wherein:

[0013] FIG. **1** shows a simple comparison between the AMLCD and PMLCD;

[0014] FIG. **2 (A)** is a cross-sectional view of a reflection type liquid crystal display in accordance with the present invention;

[0015] FIG. **2 (B)** is a top plan view, illustrating a configuration of a first upper electrode and a second upper electrode on an upper transparent substrate in accordance with the present invention;

[0016] FIG. **2 (C)** is a top plan view, illustrating a configuration of a first lower electrode and a second lower electrode on a lower transparent substrate in accordance with the present invention;

[0017] FIG. **3** is cross-sectional view of the reflection type liquid crystal display, illustrating a reflective layer made over the lower transparent substrate in accordance with the present invention;

[0018] FIG. **4** is a cross-sectional view of the reflection type liquid crystal display having two matrix modes converged within a panel in accordance with the present invention; and

[0019] FIG. **5** is a cross-sectional view of the reflection type liquid crystal display having two matrix modes converged within a panel in accordance with the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0020] The invention disclosed herein is directed to a reflection type liquid crystal display (LCD) having at least two matrix modes converged within a panel, wherein one of the two matrix

modes is an active matrix mode. When the reflection type liquid crystal display LCD is applied to a portable terminal device, the different demand for displays can be satisfied by switching between different matrix modes. For example, the passive matrix mode is activated to address the image formation satisfying the demand of lower resolution and slower switching, whereas the active matrix mode is activated satisfying the demand of higher resolution and faster switching. Hence, the different demand of users can be easily satisfied and the electrical consumption of the portable terminal device can be effectively saved. The embodiments of the present invention are now described in detail below.

Embodiment 1

[0021] Referring to FIG. **2 (A)**, the reflection type LCD **50** comprises a lower transparent substrate **52**, an upper transparent substrate **54**, a color filter **56**, a first transparent insulating layer **58**, a reflective layer **60**, a second transparent insulating layer **62**, first lower and upper electrodes **64a** 、 **64b**, a third transparent insulating layer **66**, a fourth transparent insulating layer **68**, second lower and upper electrodes **70a** 、 **70b**, a first transparent alignment film **72**, a second transparent alignment film **74** and a liquid crystal layer **76**. A plurality of thin film transistors (TFTs) (not shown) and a color filter **56** are fabricated on the opposing inner surfaces of the lower and upper transparent substrate **52** and **54** respectively made of glass or plastics, wherein the TFTs are served as electronic switches. The first transparent insulating layer **58** is formed on the lower transparent substrate **52** to cover the TFTs and to provide insulation and planarization.

[0022] The reflective layer **60** is formed on the first transparent insulating layer **58**. Now referring to FIG. **3**, the reflective layer **60** comprises an insulator ***60a*** and a reflector ***60b***. On the

upper surface of the insulator **60*a*** have a plurality of bumps **60*c*.**. Because of the bumps **60c** on the insulator **60a**, the reflector **60b** formed on the insulator **60a** will have an uneven surface.

[0023] Referring back to FIG. **2 (A)**, the second transparent insulating layer **62** is formed on the reflective layer **60**. The first set of electrodes **64** includes a first lower electrode **64*a*** and a first upper electrode **64*b***, wherein the first lower electrode **64*a*** is fabricated on the second transparent insulating layer **62**. In an embodiment of the present invention, the material of the first lower electrode **64*a*** is indium tin oxide (ITO), a conductor with high transparence. The first upper electrode **64*b*** is formed on the aforesaid color filter **56**. As just mentioned, the first upper electrode **64*b*** preferably comprises ITO. Upon the first lower electrode **64*a*** and the first upper electrode **64*b*** are formed respectively the third transparent insulating layer **66** and fourth transparent insulating layer **68**.

[0024] Still referring back to FIG. **2 (A)**, the second set of electrodes **70** comprises a second lower electrode **70*a*** and second upper electrode **70*b***. The second lower electrode **70*a*** is formed on the third transparent insulating layer **66**, whereas the second upper electrode **70*b*** is formed on the fourth transparent insulating layer **68**. In an embodiment of the present invention, the second lower electrode **70*a*** and second upper electrode **70*b*** are made of ITO. The first transparent alignment film **72** and the second transparent alignment film **74** are formed on the second lower electrode **70*a*** and the second upper electrode **70*b***, respectively. The liquid crystal layer **76** is sandwiched between the first and the second transparent alignment films **72** and **74**.

[0025] While the first set of electrodes **64** set is activated optionally to address the liquid crystal molecules to twist, a voltage of the first lower electrode **64*a*** will be influenced by the second lower electrode **70*a*** since both of them are made of conductive materials. For example, when applying 5 volts to the first lower electrode **64*a***, the second lower electrode **70*a*** over the first

lower electrode **64*a*** will be induced approximately to have a parasitic voltage of 1 volt. Thus, the developing image addressed by the first lower electrode **64*a*** will be influenced by the second lower electrode **70*a***.

[0026] In order to solve the problem described above, dispositions of the first lower electrode **64*a*** and the second lower electrode **70*a*** are preferably staggered.

[0027] Referring to FIGS. **2 (B)** and **2 (C)**, the FIG. **2 (B)** is a top plan view illustrating a configuration of the first upper electrode **64*b*** and the second upper electrode **70*b*** on the upper transparent substrate **54**, whereas the FIG. **2 (C)** shows a top plan view illustrating a configuration of the first lower electrode **64*a***, the second lower electrode **70*a***, a plurality of scan lines **71** and signal lines **73** (not shown in FIG. **2 (A)**) on the lower transparent substrate **52**. As shown in FIG. **2 (C)**, the first lower electrode **64*a*** and the second lower electrode **70*a*** fabricated over the lower transparent substrate **52** are staggered to prevent an undesired electric interference occurred between two conductive layers.

[0028] The first upper electrode **64*b*** shown in FIG. **2 (B)** comprises parallel sets of column electrodes, and the first lower electrode **64*a*** shown in FIG. **2 (C)** comprises parallel sets of row electrodes. The row and column configuration forms a matrix. When applying two respective voltages to a column electrode and a row electrode, alignments of the liquid crystal molecules are altered by a potential difference produced at an intersection between the row and column electrodes (i.e. a pixel). As shown in the figure, the second lower electrode **70*a*** is electrically connected to drains of the TFTs. Source and gates of the TFTs are in contact with the signal lines **73** and the scan lines **71**, respectively. While the TFTs are turned on, alignments of the liquid crystal molecules are altered by a potential difference produced between the second lower electrode **70*a*** and the second upper electrode **70*b***.

[0029] Another way to prevent the undesired electric interference is supplying a 1 volt of negative voltage to the second lower electrode **70*a*** at time of applying 5 volts of positive voltage to the first lower electrode **64*a*** such that the parasitic voltage of 1 volt positive induced at the second lower electrode **70a** can be neutralized. Hence, the accuracy of the image development is effectively improved.

[0030] One of the first lower electrode **64*a*** and the second lower electrode **70*a*** is electrically connected to the drains of the TFTs. In other words, one of the first electrode **64** and the second electrode **70** comprises an active matrix mode.

[0031] It is noted that the first upper electrode **64*b*** and the second upper electrode **70*b*** can be manufactured alone over the upper transparent substrate **54** to serve as a common electrode for the first lower electrode **64*a*** and the second lower electrode **70*a***. As illustrated above, the gray scale of the pixels can be determined optionally by applying two respective voltages to the first lower electrode **64*a*** and the common electrode, which serves as row and column electrodes respectively herein. Otherwise, the common electrode can be electrically connected to a referenced potential. When the second lower electrode **70*a*** is supplied with another potential, a difference of the potential between the common electrode and the second lower electrode **70*a*** alters alignments of liquid crystal molecules.

[0032] In one embodiment of the present invention, the reflective layer **60** is used to reflect and diffuse the incident light entering from the upper transparent substrate **54**. In another embodiment, the reflective layer **60** is perforated. The perforated reflective layer **60** not only reflects and diffuses the incident light, but also allows the light emitting from a backlight module on the rear side of the lower transparent substrate **52** to pass through while the incident light is

weak. Thus, the brightness of the display is enhanced when the electrical device is used under an environment without sufficient light. In a further embodiment, the thickness of the reflective layer **60** is ranges from 50 to 1000 angstroms to achieve all purposes illustrated herein.

[0033] The goal of the present invention is to converge at least two matrix modes within a panel. However, modifications can be made as illustrated below.

Embodiment 2

[0034] Referring to FIG. **4**, a modification differing from the Embodiment 1 is to interchange the reflective layer **60** with the first lower electrode ***64a***.

Embodiment 3

[0035] Referring to FIG. **5**, upon the lower transparent substrate **52** are grown a first transparent insulating layer **58**, a first lower electrode ***64a***, a second transparent insulating layer **62**, a second lower electrode ***70a***, a third transparent insulating layer **66**, a reflective layer **60**, a first transparent alignment film **72** in turn.

[0036] Since two sets of electrodes of the present invention are converged within a panel, the size and the weight of the portable terminal device can be lowered. When the portable terminal device is standby, the passive matrix mode is activated optionally to save electrical consumption; while the portable terminal device is in use, the active matrix mode is activated optionally to

obtain a higher resolution. In addition, two sets of electrodes of the present invention are converged within one panel, so that the cost and complexity of the manufacturability can be reduced. Further, the reflective layer of the display can be perforated or ground to allow the light emitting from a backlight module to pass through under the condition of insufficient incident light, thus the drawbacks of using the backlight module or the incident light alone can be avoided.

[0037] Various other modifications will be apparent to and can be readily mad by those skilled in the art without departing from the scope and spirit of this invention. Accordingly, it is not intended that the scope of the claims appended hereto be limited to the description as set forth herein, but rather that the claims be broadly construed.